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Impact of horticulture on *Banksia* woodlands

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Introduction

Horticultural production in Western Australia was valued at \$200M for the year ending 30/6/87 of which 44% (\$90M) was vegetables, 35% (\$70M) fruit and 20% (\$40M) nurseries and cut flowers. The sands (Spearwood, Karrakatta and Bassendean) are important soils for the production of vegetables, flowers and to a lesser extent fruits such as citrus, avocadoes and strawberries. The alluvial soils of the Pinjarra plain such as the neutral red earths (Belhus) in the Guildford/Swan area are preferred for the production of grapes.

About 40% of Western Australia's vegetables (2 726 ha) are grown on these sands in the Perth region (Moore to Serpentine River) of the coastal plain. The area planted to fruit on the sands (including some grapes) is much less significant being currently *c* 4.0% of total State plantings (301 ha). It has increased substantially in recent years with a big increase in plantings of avocadoes (45% of WA) and citrus (especially oranges) near Gingin (20% of WA). There are about 360 ha of nurseries and flower crops (both sheltered and field plantings) representing about 36% of the State total.

Most of the vegetables grown in the region are exported. They set the quality standard in Asia and distinguish the Swan Coastal Plain as one of the most important of vegetable production regions in the southern hemisphere.

In this paper we summarize the impact of horticulture on the coastal plain, make some projections for the future, and discuss what is currently being done to reduce problems and minimize any in the future.

Current Management and Impact

Total area

The total area of land in the Perth region of the coastal plain (Moore to Serpentine Rivers) is 380 000 ha or about 34% of the total area of the coastal plain (1.125 Mha)(Allen 1981). Nearly 80% of the total area (*c* 300 000 ha) of the plain in the Perth region is sands (Bassendean, Karrakatta, Spearwood). The area of sands under horticultural crops in the Perth region is around 3 400 ha or just over 1.0% of the total area. This is small compared with the area of other activities such as urbanization and pine forests which currently cover *c* 55 000 and 22 000 ha respectively. The impact of horticulture on other components of the system (soils, water) is now considered.

Soil

Physical properties

The soils of the *Banksia* woodlands have little natural structure. The negative impact of horticulture on the structure of the Bassendean, Karrakatta and Spearwood sands has therefore been negligible. In fact the structure of these sands has almost certainly been improved by extensive additions of organic amendments such as poultry manure (10-100 m^3 ha^{-1}).

Clearing land usually exposes the soil to erosion of some type (wind, water). The Bassendean (Jandakot, Joel, Gavin) sands have developed on wind blown material thus they are particularly vulnerable to wind erosion following the removal of vegetative cover. Sprinklers are used to stabilize sandy soils during windy periods to prevent sand blasting of tender seedlings or rendering leafy vegetables unmarketable through direct wind damage or sand. There is some use of artificial windbreaks such as Paraweb® for protecting vegetable crops on the coastal plain but little use of trees.

Chemical properties

The sands of the coastal plain are highly leached and therefore very infertile in their natural state with the Bassendean and Karrakatta sands being more infertile than the Spearwood sands. Almost all the macronutrients (N, P, K, S, Mg, Ca) and micronutrients (Cu, Zn, Mn, B, Mo, Fe) regarded as essential for plant growth must be added as inorganic or organic fertilizers for the production of vegetables, fruits and exotic flowers on the coastal sands.

In addition these sands have low capacity to adsorb cations and anions. As these nutrients readily leach, it is not possible to build up a nutrient bank in these sands to any extent and regular applications of fertilizers for crop production are required. The sands differ in their capacity to adsorb P with the Bassendean sands having the lowest adsorption capacity ($<$ 2 ppm P) and the Spearwood sands the highest (10-15 ppm P) (Ozanne & Shaw 1967). Nutrients not used by the crop are prone to leaching from the soil into ground and surface waters. This problem is exacerbated by over-irrigation. Bassendean and Karrakatta sands have been extensively leached of $CaCO_3$ and have low pH ($\leq$ 5.0-6.5) in their natural states. These soils require liming prior to fruit and vegetable production as only a limited number of crops are productive at low pH (potato, sweet potato, watermelon, rhubarb). The Spearwood sands are not as leached and are normally neutral to alkaline in reaction in their virgin state. Regular liming of Bassendean and Karrakatta sands is necessary to maintain pH when used for vegetable production.

As the coastal sands have low capacity to hold either water or nutrients, salt build up is not a problem since it is readily leached.

Water

Quantity

The annual consumption of groundwater from the superficial aquifer was 223×10^6 m^3pa in 1985/86 of which 38×10^6 m^3 (17%) was for irrigated agriculture. The quantity used for horticulture is *c* 32×10^6 m^3 or *c* 15% of total ground water consumption. Thus the impact of horticulture on total water supplies is much greater than on total land area (*c* 1%) in the Perth region. The future of horticulture on the Swan coastal plain depends on an adequate supply of good quality ($\leq$ 500-750 mg salts L^{-1})

ground water. Currently about 66% of the total annual renewable recharge of groundwater in the superficial aquifers in the Perth region is consumed (337 x 10^6 m^3 pa). Much of the remaining 33% in the superficial aquifers would also be suitable for irrigation of most crops.

Quality

Groundwater sources in the Jandakot and Wanneroo licence areas are used for blending with dam water for drinking. Fertilizers leached from horticultural properties on sands may lead to increased levels of nutrients in ground water especially when irrigation is in excess of soil water holding capacity. Nutrients of most concern are nitrate, sulphate and salt.

Nitrate and sulphate

High levels of nitrate in drinking water have led to health problems such as methaemoglobinaemia in infants. Thus upper limits (10 mg L^{-1}, NO_3 N) are put of the level of nitrate considered safe in water destined for human consumption. Nitrate is very mobile in soils and is leached even in heavily textured soils. There is a positive correlation between urbanization, horticultural activities and nitrate levels in groundwater in the superficial aquifers on the Swan Coastal Plain (Cargeeg *et al* 1987). Nitrate in groundwater is higher (> 10 mg L^{-1} NO_3, N) under suburbs with a high incidence of septic tanks (*eg* Applecross). Vegetable production has been implicated in high levels of nitrate found in some bores (1-29 mg L^{-1} NO_3, N) in the Gwelup groundwater area. Nitrate levels in water outside the urban areas is well below potable limits. Sulphate (SO_4) concentrations in excess of 400 mg L^{-1} are considered unsafe for drinking. High concentrations of sulphate (> 200 mg L^{-1}) have been recorded in groundwater near the coast between Woodman Point and Kwinana. This is probably associated with industrialization rather than any other activities. Fertilizers applied to vegetables may have resulted in elevated sulphate levels in the groundwater in some bores in the Gwelup area. Nevertheless these were well below potable limits of 400 mg L^{-1}.

Salt

High salt in water ($\geqslant$ 500-750 mg L^{-1}) severely limits the range of crops than can be grown. Very few vegetable crops (Asparagus, Silver beet) can tolerate high salinity. The best quality water (< 150 mg salt L^{-1}) occurs at the crest of the Jandakot and Gnangara groundwater mounds. Salinity increases (> 500 mg L^{-1}) from the crest of the mount to the coast. By far the biggest risk to the quality of groundwater in the Perth region of the coastal plain is the intrusion of the salt water wedge in coastal areas due to overpumping from the large number domestic (88 000) and agricultural bores.

Surface Waters

Oligotrophic surface water systems such as estuaries, rivers and lakes are characterized by low levels of P (*ie* usually < 0.1 mg L^{-1}). These systems are vulnerable to eutrophication if P inputs increase substantially. P L^{-1} leached from soils where fertilizers have been applied to agricultural (pastures) and horticultural (vegetables) crops in the catchments of the Harvey, Murray and Serpentine Rivers have been implicated in the eutrophication of the Peel Inlet and Harvey Estuary. Whilst most (85%) of the P originates from fertilizers applied to agricultural land about 5% originates from vegetable land and 10% from intensive animal (piggeries, sheep holding yards) industries. Given the high rates of P applied to horticultural crops such as vegetables (30-120 kg P ha^{-1} $crop^{-1}$) cf pastures (8.5 kg P $ha^{-1}yr^{-1}$; Kinhill Engineers 1988) any large scale expansion of horticultural activities on sands with very low P absorption capacity (*eg* Bassendean sands) could see this quantity increase substantially. At present horticultural crops are grown on 536 ha respresenting 0.26% of the coastal plain portion of the catchment area. Only a small percentage of wetlands of the *Banksia* woodlands are close to their pristine condition (Halse 1988). Almost all the remaining wetlands are nutrient enriched *ie* P concentration of water in excess of 0.04 mg L^{-1} (Chalmers & Davis 1988). Horticulture along with intensive animal enterprises, industry and urbanization has contributed to this nutrient enrichment and associated algae pollution.

Future Impact and Management

Horticultural production in Western Australia is predicted to at least double by the year 2011. The greatest impact will be on the water resources (both quantity and quality) of *Banksia* woodland.

Water quantity

Demand for groundwater will intensify considerably above the current 32 x 10 m^3 pa with the predicted expansion in horticulture. Horticulture will most likely be forced to access more unconfined groundwater either further north (Lancelin) or south (Scott River). Confined water from the Leederville and Yarragadee formations may increasingly be used for horticulture although supplies from this source are much smaller than the unconfined sources. Growers will be pressured to improve their efficiency of water use through crop selection and irrigation management. Improved irrigation management will also aid in the reduction of nutrient leaching. Movement of horticulture expecially vegetables greater distances from the metropolitan area will increase costs (freight) and reduce quality (especially leafy vegetables).

Fertilizer Management and Water Quality

Increased horticultural production will increase the pressure on groundwater and surface water quality.

Improved fertilizer management to reduce nutrient pollution of ground and surface waters of the coastal plain is a major challenge facing horticulture currently. Fertilizers have not traditionally been a major production cost (c 5-15% of direct costs of production) in horticultural crops and growers have tended to oversupply fertilizers since the financial penalties of under fertilization, especially with vegetables, are severe. Growers will be pressured to increase their efficiency of fertilizer management as water pollution presents a major cost to the community. Management strategies likely to be employed include preservation of better quality soils (Spearwood rather than Bassendean sands) for vegetable production, more regular fertilizer applications in smaller quantities (compared with less frequent and larger applications) to more closely match nutrient supply to crop demand and the use of soil and plant testing to monitor fertilizer programmes. The use of amendments high in Fe and Al oxides and hydroxides such as 'red mud' (Barrow 1982) and lateritic loams to increase the P absorption capacity of the Bassendean and Karrakatta sands may also be included in a strategy to minimize the impact of horticulture of the ground and surface waters of the coastal plain. Improved irrigation management (as mentioned above) will be an integral part of this programme.

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